

Making Cycling Irresistible: Lessons from the Netherlands, Denmark, and Germany

John Pucher and Ralph Buehler
Bloustein School of Planning and Public Policy
Rutgers University
33 Livingston Avenue, Room 363
New Brunswick, New Jersey 08904 USA
Tel: 001-732-932-3822, ext. 722
Fax: 001-732-932-2253
Email: pucher@rci.rutgers.edu; JohnPucher@gmail.com;
ralphbu@eden.rutgers.edu; Ralph.Buehler@gmail.com

Abstract

This paper investigates how bicycling can be made a safe, convenient, and practical way to get around cities. The policies and programs needed to generate high overall levels of cycling are the same policies and programs that encourage a wide spectrum of social groups to cycle: extensive systems of separate cycling facilities, intersection modifications and priority bicycle traffic signals, traffic calming of neighborhoods, safe and convenient bike parking, coordination and integration of cycling with public transport, traffic education and training for both cyclists and motorists, and traffic laws that favor cyclists and pedestrians. This paper examines successful policies in the Netherlands, Denmark, and Germany, which have achieved impressive levels of cycling among almost all social groups. For comparison, the paper portrays the marginal status of cycling in the UK and USA, where only about one percent of trips are by bike.

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**by John Pucher and Ralph Buehler
Rutgers University**

Introduction

For readers in many countries, the title of this paper might sound so impossible as to seem absurd. Most British, Americans, and Australians, for example, must find cycling quite resistible indeed, since they make only about one percent of their trips by bike. Cycling conditions in most countries—including the UK, USA, and Australia—are anything but safe, convenient, and attractive (Tolley 2003; McClintock, 2002; Pucher and Dijkstra, 2003). Bicycling in much of the world is a marginal mode of transport, occasionally used for recreational purposes but rarely used for practical, everyday travel needs. Moreover, the social distribution of cycling tends to be very uneven, with young men doing most of the cycling, while women cycle far less, and the elderly hardly cycle at all.

Thus, it may come as a surprise to skeptical readers that there are technologically advanced, affluent countries that have managed to make cycling a mainstream mode of transport, a perfectly normal way to get around cities. As documented later in this paper, cycling levels in the Netherlands, Germany, and Denmark are more than ten times higher than in the UK, USA, and Australia. Dutch, German, and Danish women cycle as often as men, and as they get older, their rates of cycling fall only slightly. Moreover, cycling is distributed evenly over all income groups. In the Netherlands, Germany, and Denmark, cycling is truly for everyone and for all trip purposes (Dutch Bicycling

Federation, 2006; German Federal Ministry of Transport, 2002). Cycling in those countries is not viewed as requiring expensive equipment, advanced training, or a high degree of physical fitness. Moreover, cyclists are not required to muster the courage and willingness to battle motor vehicles on streets without separate bike lanes or paths. On the contrary, Dutch, German, and Danish cyclists ride on simple, inexpensive bikes, almost never wear special cycling outfits, and rarely use safety helmets.

As documented in this paper, cycling was not always thriving in the Netherlands, Germany, and Denmark. Cycling levels plummeted in all three countries from about 1950 to 1975. It was only through a massive reversal in transport and urban planning policies in the mid 1970s that cycling was revived to its current successful state. In 1952, cycling levels were higher in the UK than they are now in Germany: 454 km vs. 368 km per capita (German Federal Ministry of Transport, 2007; Department for Transport, 2007). Just as in these other countries, cycling in the UK plummeted from 1952 to 1975, but British cycling never recovered. It continued to fall to its current level of one percent of trips, the same bike modal share as in the USA.

History, culture, topography, and climate do not necessarily determine the ultimate fate of cycling. Government policies are at least as important: transport policies, land use policies, urban development policies, housing policies, environmental policies, taxation policies, and parking policies. In many respects, the UK, USA, and Australia have given the green light to the private car, almost regardless of its enormous economic, social, and environmental costs (Banister, 2005). In sharp contrast, cycling has prospered in the Netherlands, Germany, and Denmark over the past three decades precisely because these countries have given the red light, or at least the yellow warning

light, to car use in their cities. Instead of catering to ever more urban car use by expanding roadways and parking facilities, Dutch, German, and Danish cities have focused on serving people, making their cities people-friendly rather than car-friendly, and thus more livable and more sustainable than American, British, and Australian cities.

There are more than enough good reasons to encourage more cycling (McClintock, 2002; Tolley, 2003). It causes virtually no noise or air pollution, and consumes far less nonrenewable resources than any motorized transport mode. The only energy cycling requires is provided directly by the traveler, and the very generation of that energy offers valuable cardiovascular exercise. Cycling requires only a small fraction of the space needed for the use and parking of cars. Moreover, cycling is quite economical, costing much less than both the private car and public transport, both in direct user costs and public infrastructure costs. Precisely because it is affordable by virtually everyone, cycling is among the most equitable of all transport modes. In short, it is hard to beat cycling when it comes to environmental, social, and economic sustainability. Consequently, both the European Union and the United States have officially recognized the importance of cycling as a practical mode of urban transport and endorse the dual objectives of raising cycling levels while increasing cycling safety (European Conference of the Ministers of Transport, 2004; U.S. Department of Transportation, 1994 and 2004).

As shown in this paper, there is great variation among countries in the degree to which these stated objectives have been met. The Netherlands, Denmark, and Germany have been at the forefront of policies to make cycling safe, convenient, and attractive, while the UK and USA have lagged far behind. Differences in cycling levels between

these countries are enlightening because all five of them are highly democratic, capitalist, affluent societies with nearly universal car ownership. The success of cycling does not depend on poverty, dictatorial regimes, or the lack of transport options to force people onto bikes. This paper shows how the Netherlands, Denmark, and Germany have managed to make cycling a popular, mainstream way of getting around cities.

First, however, we document differences among countries in their overall levels of cycling, in bike trip purposes, and in the gender, age, and income levels of cyclists. Differences in cycling safety help explain some of the difference in cycling levels among countries; thus, the paper contains an entire section with comparisons of cycling fatality and injury rates and trends over time. The subsequent sections of the paper summarize the range of policies and programs used in the Netherlands, Denmark, and Germany to promote cycling by a broad spectrum of society and at the same time improve cycling safety. The paper concludes with an overall assessment of the lessons than can be learned from these countries to make cycling safer, more convenient, and more attractive in other countries as well.

Variations among Countries in Overall Cycling Levels

As shown in Figure 1, there are large differences between Australia, the United States, Canada, and European countries in the bike share of trips, ranging from a low of only 1% in Australia, the UK, and the USA to 27% in the Netherlands. These differences in the bike share of trips roughly parallel differences in the average distance cycled per person per day, an alternative way of measuring and comparing cycling levels among countries. Averaging over the entire population of each country, the European Conference of the Ministers of Transport (2005) estimated that per capita cycling per day

ranges from a low of only 0.1 km in Spain, Greece, and Portugal to a high of 2.5 km in the Netherlands (see Figure 2). Germany (0.9 km) and Denmark (1.6 km) are near the top, immediately following the Netherlands in distance cycled per inhabitant. The USA and UK are both at the low end of the spectrum, averaging 0.1 km and 0.2 km of cycling per person per day, respectively.

One might expect that Europeans cycle more than Americans due to shorter trip lengths in European cities. In fact, a considerably higher percentage of all trips in European cities are shorter than 2.5 km: 44% in the Netherlands, 37% in Denmark, and 41% in Germany, compared to 27% in the USA. In the UK, only 30% of trips are shorter than 2.5 km, much closer to the American level, probably due to the extensive American-style sprawl in much of Britain.

Even controlling for trip distance, however, the Dutch, Danes, and Germans make a much higher percentage of their local trips by bike. As shown in Figure 3, both Americans and the British cycle for only 2% of their trips shorter than 2.5km, compared to 37% in the Netherlands, 27% in Denmark, and 14% in Germany. That pattern also holds for the progressively longer trip distance categories shown in Figure 3. For trips between 2.5km and 4.4km, for example, Americans and the British make only 1% of their trips by bike, compared to much higher bike mode shares for the same trip distance in the Netherlands (37%), Denmark (24%), and Germany (11%).

Northern Europeans—even the British—are far more likely than Americans to cycle for practical, utilitarian purposes. Travel to work or school accounts for only 11% of all bike trips in the USA, compared to 22% in Germany, 30% in the UK, and 32% in the Netherlands. Even more strikingly, shopping trips account for only 5% of all bike

trips in the USA, compared to 20% in Germany and 22% in the Netherlands. Roughly three-fourths of all bike trips in the USA are for recreation, compared to 38% in Germany, 35% in the UK, 27% in the Netherlands, and 24% in Denmark (U.S. Department of Transportation, 2003; German Ministry of Transport, 2003; Dutch Ministry of Transport, 2006; Department for Transport, 2007).

The Netherlands, Denmark, and Germany have been among the most successful countries at promoting cycling for daily travel. Since these three countries are quite affluent, their high levels of cycling are not due to the inability to afford more expensive transport modes. Indeed, the three countries have levels of car ownership that are among the highest in the world. An examination of their successful pro-cycling policies and programs may provide especially useful lessons for increasing cycling in other countries with high incomes and widespread car ownership.

Some readers might assume that bicycling levels in Europe have been consistently high, but they fell sharply during the 1950s and 1960s, when car ownership increased rapidly and cities started spreading out. A Dutch study showed that, from 1950 to 1975, the bike share of trips fell by roughly two-thirds in a sample of Dutch, Danish, and German cities, from 50-85% of trips in 1950 to only 14-35% of trips in 1975 (Dutch Cycling Federation, 2006). Similarly, a study by the City of Berlin (2003) found that the number of bike trips there fell by 78% from 1950 to 1975. During that 25-year period, cities throughout the Netherlands, Denmark, and Germany focused on accommodating and facilitating increased car use by vastly expanding roadway capacity and parking supply, while largely ignoring the needs of pedestrians and cyclists (Hass-Klau, 1990).

In the mid-1970s, transport and land use policies in all three countries dramatically shifted to favor walking, cycling, and public transport over the private car (Hass-Klau, 1990; Pucher, 1997; Dutch Bicycling Federation, 2006). Most cities vastly improved their bicycling infrastructure while imposing ever more restrictions on car use and making it more expensive. That policy reversal led to turnarounds in the previous decline of bike use. From 1975 to 1995, the bicycling share of trips in the same, previously cited sample of Dutch, Danish, and German cities rose by roughly a fourth, resulting in 1995 bike shares of 20-43%. In Berlin, the total number of bike trips quadrupled from 1975 to 2001 (increasing by 275%), reaching 45% of the 1950 bicycling level (City of Berlin, 2003). The rebound in cycling from 1975 onward was not enough to offset the huge declines from 1950 to 1975, but quite an accomplishment nevertheless, and evidence of the powerful impact of policy on travel behavior. It is especially impressive given the continuing growth in per-capita income, car ownership and suburban development in all three countries over the past three decade (Organisation for Economic Cooperation and Development, 2005).

The Netherlands and the UK provide striking contrasts in their long-term cycling trends (see Figure 4). Over the period 1952 to 1975, cycling in the UK fell by 80%, compared to a drop of 62% in the Netherlands. Cycling in both countries rebounded somewhat during the ten years from 1975 to 1985. In the next 20 years, however, cycling continued its long-term decline in the UK, while cycling levels increased slightly in the Netherlands. The overall result is that by 2006, the cycling level in the UK was less than a seventh of its 1952 level (13%), while cycling in the Netherlands was at slightly more than half of its 1952 level (52%).

Analysis of nationwide aggregate data for the past few decades confirms a rebound in cycling in the Netherlands, Denmark, and Germany since the 1970s. As shown in Figure 5, average daily km cycled per inhabitant rose in all three countries over the period 1978 to 2005: from 0.6 to 1.0 in Germany, from 1.3 to 1.6 in Denmark, and from 1.7 to 2.5 in the Netherlands. By comparison, daily km cycled in the UK fell by almost a third over the same period, from .25 to .18.

Not only do the Netherlands, Denmark, and Germany have high and growing levels of cycling, but their cyclists comprise virtually all segments of society (see Figure 6). For example, women are just about as likely to cycle as men. Women make 45% of all bike trips in Denmark, 49% in Germany, and 55% in the Netherlands. While cycling is gender-neutral in those three countries, men dominate cycling in the UK and USA, where they make 72% and 76% of all bike trips, respectively.

Another dimension of cycling's universality in the Netherlands, Denmark, and Germany is the representation of all age groups. Children and adolescents have the highest rates of cycling in almost every country. As shown in Figure 7, however, cycling levels in the Netherlands, Denmark, and Germany remain high even among the elderly. Indeed, the bike share of trips in Germany rises steadily from 7% among 18-24-year-olds to 12% for those 65 and older. The bike share of trips declines with age in Denmark, but even among those aged 70-74 years old, cycling accounts for 12% of all trips, the same as among Germans who are 65 and older. The Dutch elderly double that percentage, making 24% of all their trips by bike.

Cycling rates are low for all age groups in the USA, but they also decline with age: from 3.2% among children 5-15 years old to only 0.4% of trips for those 40 and

older (see Figure 7). Similarly, the bike share of trips falls from 2% among British children to one percent among older age groups. The bike share of trips for the Dutch elderly is 24 times higher than for British elderly and 60 times higher than for American elderly. The bike share of trips for both the German and Danish elderly is 12 times higher than for British elderly and 30 times higher than for American elderly.

Rates of cycling are similar among different income classes. For example, the 2002 national travel survey in Germany revealed that the lowest-income quartile was only slightly more likely to travel by bike (10% of trips) than the highest-income quartile (8.3%) (German Federal Ministry of Transport, 2003). Similarly, cyclists are distributed evenly among income classes in the Netherlands and Denmark (Dutch Ministry of Transport, 2006; Dutch Cycling Federation, 2006).

The remainder of this article examines how Germany, the Netherlands, and Denmark have succeeded in making cycling a safe and convenient way to get around their cities.

Trends in Cycling Safety

Perhaps the most important reason for the higher levels of cycling in the Netherlands, Denmark, and Germany—especially among women, children, and the elderly—is that cycling is much safer there than in the USA and the UK. Both fatality and injury rates are much higher for cyclists in the USA and the UK than in Germany, Denmark, and the Netherlands. Averaged over the years 2002 to 2005, the number of bicyclist fatalities per 100 million km cycled was 5.8 in the USA and 3.6 in the UK, compared to 1.7 in Germany, 1.5 in Denmark, and 1.1 in the Netherlands (see Figure 8). Thus, cycling is over five times as safe in the Netherlands as in the USA and more than

three times as safe as in the UK. That might explain why the Dutch do not perceive cycling as a dangerous way to get around. Cycling in Germany and Denmark is not quite as safe as in the Netherlands, but still 3-4 times safer than in the USA and twice as safe as in the UK.

Cycling fatalities comprise less than a tenth of serious cycling injuries in most countries. Thus, it is important to consider non-fatal injury rates as well. Figure 8 compares non-fatal injury rates per 10 million km cycled side by side with fatality rates per 100 million km cycled. Without exception, the cycling safety ranking for countries is the same for injuries as for fatalities. Thus, the Netherlands has the lowest non-fatal injury rate as well as the lowest fatality rate. And the USA has the highest non-fatal injury rate as well as the highest fatality rate. Indeed, the non-fatal injury rate for the USA is about eight times higher than for Germany and about 30 times higher than for the Netherlands and Denmark. The injury rate in the UK is second highest, but much lower than in the USA.

Most astounding of all, the high injury rate for the USA almost certainly underestimates serious cycling injuries. It only includes cycling injuries from crashes with motor vehicles on roadways, as reported by the National Highway Traffic Safety Administration of the U.S. Department of Transportation (2007). By comparison, the Center for Disease Control and Prevention (2007), the official public health agency of the U.S. Government, reports ten times more serious cycling injuries per year (479,963 vs. 45,000 in 2005), based on reports from emergency rooms of hospitals. Using the CDC's injury statistics instead of the NHTSA's statistics would result in a safety gap between

the USA and the other countries that would be ten times larger than that shown in Figure 8.

There are always problems comparing injury statistics across different countries because of differences in definitions and methodologies of data collection. Thus, the cycling injury rates reported in Figure 8 are less accurate and less comparable than the corresponding fatality rates. Nevertheless, both measures indicate much safer cycling in the Netherlands and Denmark than in the UK and the USA, with Germany in between.

As shown in Figure 9, Germany, Denmark, and the Netherlands have greatly improved cycling safety since 1970. Although levels of cycling have increased in all three countries over the past 35 years (as already shown in Figure 5), the total number of cycling fatalities has declined by over 70%. Fatalities fell by 60% in the UK over the same period, but the amount of cycling also decreased. The least improvement in cycling safety has been in the USA, where fatalities fell by only 30%.

Longer-term data are available for the Netherlands. They dramatically portray the strong relationship between cycling safety and levels of cycling (see Figure 10). During the 1950s and 1960s, car use rose rapidly in the Netherlands. Insufficient supply of both roadways and separate cycling facilities generated dangerous traffic conflicts and an alarming increase in cycling fatalities (Dutch Bicycling Federation, 2006; Netherlands Ministry of Transport, 2006). As the cyclist fatality rate per billion km cycled rose by 174% from 1950 to 1978, the average km cycled per inhabitant fell by 65%. Since the mid-1970s, Dutch cities have undertaken massive improvements to cycling infrastructure and restricted car use (Netherlands Ministry of Transport, 1999 and 2006). The result has been an 81% fall in the cyclist fatality rate from 1978 to 2006, thus encouraging a 36%

increase in km cycled per inhabitant. This statistical relationship, of course, does not prove causation, but there is every reason to believe that increased safety is a key to promoting more cycling.

There is also reason to believe that more cycling facilitates safer cycling. The phenomenon of ‘safety in numbers’ has been consistently found to hold over time and across cities and countries. Fatality rates per trip and per km are much lower for countries and cities with high bicycling shares of total travel, and fatality rates fall for any given country or city as cycling levels rise (Jacobsen, 2003).

The national bicycling plans of the USA, the UK, the Netherlands, Denmark, and Germany all conclude that the perceived traffic danger of cycling is an important deterrent to more widespread cycling (U.S. Department of Transportation, 1994; Department for Transport, 1996; Netherlands Ministry of Transport, 1999; Danish Ministry of Transport, 2000; German Federal Ministry of Transport, 2002). Women and the elderly appear to be especially sensitive to such traffic danger. Many American parents do not allow their children to cycle for the same reason. As shown in Figure 8, cycling in the USA is indeed dangerous in comparison with other countries. Thus, making cycling safer is surely one of the keys to increasing overall cycling levels in the USA, particularly among women, the elderly, and children.

In the USA, much of the effort to improve cyclist safety has focused on increasing helmet use, if necessary by law, especially for children. Thus, it is important to emphasize that the much safer cycling in northern Europe is definitely *not* due to widespread use of safety helmets. On the contrary, in the Netherlands, with the safest cycling of any country, less than one percent of adult cyclists wear helmets, and even

among children, only 3-5% wear helmets (Dutch Bicycling Federation, 2006; Netherlands Ministry of Transport, 2006). The Dutch cycling experts and planners interviewed for this paper adamantly opposed the use of helmets, claiming that helmets discourage cycling by making it less convenient, less comfortable, and less fashionable. They also mention the possibility that helmets would make cycling more dangerous by giving cyclists a false sense of safety and thus encouraging riskier riding behavior. At the same time, helmets might reduce the consideration motorists give cyclists, since they might seem less vulnerable if wearing helmets.

German and Danish cycling planners seem far more supportive of increased helmet use, especially among children. There have been extensive promotional campaigns in these two countries to encourage more helmet use, but there are no laws requiring helmet use, not even for young children. In 2002, 33% of German children aged 6-10 years wore helmets while cycling, compared to only 9% of adolescents aged 11-16, and only 2% of Germans aged 17 or older. In 2006, 66% of Danish school children aged 6-10 wore helmets, compared to 12% among school children 11 years or older, and less than 5% among adults (Andersen, 2005; Boehme, 2005; City of Muenster, 2004; Danish Ministry of Transport, 2004; German Federal Ministry of Transport, 2002).

Government Roles in Funding and Planning Cycling Facilities and Programs in the Netherlands, Denmark, and Germany

Due to the mostly local, short-distance trips made by bike, policies and programs to promote safe and convenient cycling are usually carried out at the municipal level (European Conference of the Ministers of Transport, 2004). Local governments in the Netherlands, Germany, and Denmark have been planning, constructing, and funding

bicycling facilities for many decades, at least since the 1970s but much earlier in some cities. Municipalities are responsible for making the specific plans that reflect the particular conditions and needs of the local context. Cycling training, safety, and promotional programs are usually carried out at the local level as well, even if they are mandated and funded by higher levels. At the intermediate level, states, counties, and regional governments provide additional policy guidance, coordination, and funding, as well as some direct planning and construction of cycling facilities that serve rural areas or provide links between municipalities.

Central government involvement in cycling has been more recent, evolving gradually since about 1980 and providing overall goals, design guidelines, research support, model projects, coordination, and funding. The Netherlands, Denmark, and Germany all have official National Bicycling Master Plans (Dutch Ministry of Transport, 1999; Danish Ministry of Transport, 2000; German Federal Ministry of Transport, 2002). Each of these plans sets forth the overall goal of raising levels of cycling for daily travel while improving cycling safety. They also propose various strategies to achieve these dual goals: better design of lanes, paths, and intersections; more and better bike parking; coordination with public transport; and cycling safety and promotion campaigns.

Although the Master Plans vary from one country to another, they generally focus on the federal government's role in fostering research, dissemination of best practice information, and funding and evaluation of a wide range of experimental, innovative projects.

Central governments usually bear the cost of bicycling facilities built along national highways and contribute significantly to financing long-distance bicycling routes

that cross state boundaries (European Conference of Ministers of Transport, 2004). In Germany, for example, the federal government contributed over €1.1 billion to doubling the extent of bikeways along federal highways from 1980 to 2000, and is now devoting €100 million per year for further bikeway extensions, cycling research, and demonstration projects. In addition, about €2 billion a year in revenues from the motor fuel tax are earmarked for a special urban transport investment fund, which provides 70-85% federal matching funds for state and local governments wanting to build cycling facilities (paths, lanes, bridges, traffic signals, signs, parking, etc.) (German Federal Ministry of Transport, 2002). From 1990 to 2006, the Dutch Central Government contributed an average of €60 million per year to various cycling projects, including €25 million per year specifically for bike parking at train stations. In addition, the Dutch Central Government provides €1.8 billion a year for provinces to spend on transport projects, including cycling facilities. By comparison, the Danish Central Government has no regular funding for cycling projects but since 2000 has contributed about €5 million a year to various demonstration projects (European Conference of Ministers of Transport, 2004).

The European Union (EU) has been playing a modest but increasing role in promoting cycling (European Conference of Ministry of Transport, 2004). It provides funding, for example, for transnational and cross-border bikeway projects through its EU INTERREG Funding. The European Cycling Federation (ECF) has already established a system of European-wide bicycling routes, and the EU contributes toward the funding of missing bike route connections between countries and of cycling facilities in underdeveloped regions. The EU also facilitates bicycling research and the exchange of

best practice information among EU countries, just as national governments do this within each country.

How to Make Cycling Safe and Convenient for Everyone

Many policies and programs are necessary to make cycling safe and feasible for a broad spectrum of the population. Table 1 summarizes seven categories of measures that have been widely adopted in Dutch, Danish and German cities. Their success in making cycling so appealing is largely attributable to the coordinated implementation of all of these measures, so that they reinforce the impact of each other in promoting cycling. Indeed, that is perhaps the key lesson to be learned: the necessity of a coordinated, multi-faceted approach.

Due to space limitations, we can only provide a few details to describe the nature and extent of the seven types of measures. The following discussion serves mainly to provide some representative examples of what Dutch, Danish, and German cities have been doing to raise cycling levels and make it safer. Most of the information cited below was provided directly to the authors by bicycling coordinators and planners in the ministries of transport of the Netherlands, Denmark, and Germany and in two case study cities in each country (Amsterdam and Groningen; Copenhagen and Odense; Berlin and Muenster).

Bike Paths and Lanes. Especially from the mid-1970s to the mid-1990s, separate facilities such as bike paths and lanes expanded greatly in all three countries. In Germany, for example, the bikeway network almost tripled in length, from 12,911km in 1976 to 31,236km in 1996. In the Netherlands, the bikeway network doubled in length, from 9,282km in 1978 to 18,948km in 1996 (German Federal Ministry of Transport,

1998; Statistics Netherlands, 1999; Pucher and Dijkstra, 2000). Nationwide, aggregate statistics for the period since the mid 1990s are not available, but data for individual cities suggest continued expansion, albeit at a much slower rate than previously. The main focus now appears to be on improving the specific design of cycle paths and lanes to improve safety.

In 2004, for example, Berlin (3.4 million inhabitants) had 860km of completely separate bike paths, 60km of bike lanes on streets, 50km of bike lanes on sidewalks, 100km of mixed-use pedestrian-bike paths, and 70km of combined bus-bike lanes on streets (City of Berlin, 2007) . By comparison, Amsterdam (735,000 inhabitants) and Copenhagen (504,000 inhabitants) each have roughly 400km of completely separate bike paths and lanes (City of Amsterdam, 2003; City of Copenhagen, 2004). Even much smaller cities, however, have extensive cycling facilities. For example, there are 320km of bike paths and lanes in Muenster, Germany (278,000 inhabitants), over 500km in Odense, Denmark (185,000 inhabitants), and over 420km in Groningen, Netherlands (181,000) (City of Muenster, 2004; City of Odense, 2007; Dutch Bicycling Federation, 2006). The bicycling networks in all these cities include numerous off-street short cut connections for cyclists between streets and traversing city blocks to enable them to take the most direct possible route from origin to destination. The result of all these facilities is a truly complete, integrated system of bicycling routes that permit cyclists to cover almost any trip either on completely separate paths and lanes or on lightly traveled, traffic-calmed residential streets.

Not only has the network of separate cycling facilities greatly expanded since the 1970s, but their design, quality, and maintenance have continually improved to ensure

safer, more convenient, and more attractive cycling with each passing year. In addition, most cities have established a fully integrated system of directional signs for cyclists, color-coded to correspond to different types of bike routes. That system of signage often extends to entire regions, states, and even countries for long-distance routes (City of Muenster, 2007; Andersen, 2005; City of Copenhagen, 2002).

All large cities and most medium-sized cities provide detailed maps of their cycling facilities. Some cities have recently introduced Internet bike route planning to assist cyclists in choosing the route that best serves their needs. In Berlin and Odense, for example, cyclists can enter their origin and destination as well as a range of personal preferences, such as speed, on-street or off-street facility, avoiding intersections and heavy traffic, etc. (City of Berlin, 2007; Andersen, 2005). The Internet program shows the optimal route on a map and provides all relevant information about time, average speed, bike parking, and public transport connections. This bike route planning is even possible while en route, using the LCD display of a mobile phone.

The provision of separate cycling facilities is undoubtedly the cornerstone of Dutch, Danish, and German policies to make cycling safe and attractive. They are designed to feel safe, comfortable, and convenient for both young and old, for women as well as men, and for all levels of cycling ability. Separate facilities are not sufficient but they are certainly necessary to ensure that cycling is possible for a broad spectrum of the population.

Traffic Calming. It is neither possible nor necessary to provide separate bike paths and lanes on lightly traveled residential streets, but they constitute an important part of the overall cycling route network. Thus, Dutch, Danish, and German cities have

traffic-calmed most streets in residential neighborhoods, reducing the legal speed limit to 30km/hr (19mph) and often prohibiting any thru-traffic (Hass-Klau, 1990). In addition, many cities—especially in the Netherlands—introduced considerable alterations to the streets themselves, such as road narrowing, raised intersections and crosswalks, traffic circles, extra curves and zigzag routes, speed humps, and artificial deadends created by mid-block street closures. Cycling is almost always allowed in both directions on all such traffic-calmed streets, even when they are restricted to one-way travel for cars. That further enhances the flexibility of bike travel (City of Berlin, 2007; City of Groningen, 2007; City of Odense, 2007; Boehme, 2005).

The most advanced form of traffic calming—the “woonerf” or “home zone”—imposes even more restrictions, requiring cars to travel at walking speed. Moreover, pedestrians, cyclists, and playing children have as much right to use such residential streets as motor vehicles; indeed, motor vehicles are required to yield to those non-motorized users.

In the Netherlands, Denmark, and Germany, traffic calming is area-wide and not for isolated streets. That ensures that thru-traffic gets displaced to arterial roads designed to handle it and not simply shifted from one residential street to another.

Related to traffic calming, almost every city has created extensive car-free zones in their centers, mainly intended for pedestrian use but generally permitting cycling during off-peak hours (City of Muenster, 2004; City of Copenhagen, 2002; City of Amsterdam, 2003b). In some Dutch cities, these car-free zones specifically include cycling facilities such as bike lanes and parking (Dutch Bicycling Federation, 2006). The combination of traffic calming of residential streets and prohibition of cars in city centers

makes it virtually impossible in some cities for cars to traverse the city center to get to the other side. Cars are forced to take various circumferential routes instead, thus mitigating the congestion, pollution, and safety problems they would cause in dense city centers.

Another kind of traffic calming is the so-called “bicycle street,” which has been increasingly adopted in Dutch and German cities. These are narrow streets where cyclists are given absolute traffic priority over the entire width of the street. Cars are usually permitted to use the streets as well, but they are limited to 30km/hr (or less) and cannot rush bicyclists or otherwise interfere with them. In Muenster, for example, there were already 12 bicycling streets in 2007, and they have been so successful that the city has plans to add another 10 bicycling streets in the coming years (City of Muenster, 2007).

Traffic calmed residential neighborhoods, car-free city centers, and special bicycle streets all greatly enhance the overall bicycling network in all Dutch, Danish, and German cities. Most importantly, they offer much safer, less stressful cycling than streets filled with fast-moving motor vehicles. Since most bike trips start at home, traffic calming of neighborhood streets is crucial to enabling bike trips to start off in a safe, pleasant environment on the way to the separate bike paths and lanes that serve the rest of the trip.

Intersection modifications. While bike paths and lanes help protect cyclists from exposure to traffic dangers between intersections, they can pose safety problems when crossing intersections. Thus, Dutch, Danish, and German planners have worked continuously on perfecting the designs of intersections to facilitate safe cyclist crossings (City of Copenhagen, 2002; Dutch Bicycling Federation, 2006; City of Berlin, 2003).

The extent and specific design of intersection modifications vary, of course, from city to city, but they generally include most of the following:

- Special bike lanes leading up to the intersection, with advance stop lines for cyclists, far ahead of waiting cars
- Advance green traffic signals for cyclists, and extra green signal phases for cyclists at intersections with heavy cycling volumes
- Turn restrictions for cars, while all turns allowed for cyclists
- Highly visible, distinctively colored bike lane crossings at intersections
- Special cyclist-activated traffic lights
- Timing traffic lights to provide a “green wave” for cyclists instead of for cars, generally assuming 14km/hr bike speed
- Insertion of traffic islands and bollards in roadway to sharpen turning radius of cars and thus force them to slow down when turning right
- Realigning bike pathways a bit further away from their parallel streets when they approach intersections to help avoid collisions with right-turning cars

Given the very nature of roadway intersections, it is virtually impossible to avoid all conflicts between motor vehicles and cyclists, but Dutch, Danish, and German planners have done a superb job of minimizing these dangers.

Bike Parking. Extensive bike parking of various sorts is available throughout most Dutch, Danish, and German cities. Local governments and public transport systems themselves directly provide a large number of bike parking facilities. Moreover, private developers and building owners are required by law to provide specified minimum levels

of bike parking both within and adjacent to their buildings (City of Berlin, 2005; Dutch Cycling Federation, 2006).

Aside from the large number of bike racks throughout these cities, the most visible and most innovative aspect of bike parking policy is the provision of state-of-the-art parking facilities at train stations. Immediately adjacent to Muenster's main train station, for example, there is a modern, attractive "bike station" (built in 1999) that offers secure, indoor parking for 3,300 bikes as well as bike repairs, bike rentals, and direct access to all train platforms (Boehme, 2005). Amsterdam, Groningen, Odense, and Copenhagen offer similar, high-capacity bike parking facilities at their main train stations (Langenberg, 2000; City of Copenhagen, 2004; City of Odense, 2007; City of Groningen, 2007). Moreover, virtually every train station throughout Dutch, Danish, and German metropolitan areas offers bike parking of some sort. In the Berlin region, there were 24,600 bike-and-ride parking spots at train stations in 2005 (including metro, suburban rail, and regional rail), with 7,000 additional bike parking spots planned by 2010 (City of Berlin, 2007).

Many city centers also offer special bike parking facilities. The City of Odense, for example, recently added 400 sheltered bike racks near its main shopping area as well as a state-of-the-art automatic, secure parking station (Andersen, 2005). Groningen offers 36 major bike parking facilities in its town center, including seven that are guarded to prevent bike theft (Dutch Bicycling Federation, 2006). Amsterdam has 15 guarded bike parking facilities in its downtown shopping area (City of Amsterdam, 2007). In 2007, Muenster added a secured, indoor parking facility for 290 bikes adjacent to its main shopping district (City of Muenster, 2007). The City of Copenhagen installed 3,300 bike

parking spaces in the town center to facilitate cycling for shopping and entertainment trips (City of Copenhagen, 2007).

Clearly, the provision of convenient, secure, sheltered bike parking is essential to cyclists, just as car drivers need parking for their cars. The current policy focus in Dutch, Danish, and German cities is to increase the security of bike parking, since bike theft is a major problem. Moreover, the random parking of bikes in public spaces is viewed by most as a visual eyesore and obstacle to pedestrians on sidewalks. Thus, the supply of bike parking is being expanded not only for greater cyclist convenience but also to deal with the clutter of randomly parked bikes.

Somewhat similar to car parking in the USA, there never seems to be enough bike parking. In spite of Muenster's superb bike parking facility at the main train station, for example, there are still over 10,000 bikes parked in the nearby sidewalks, plazas, and alleys, and most of those are not in racks (Boehme, 2005).

Integration with Public Transport. Most Dutch, Danish and German cities have integrated cycling with public transport. Public transport systems and city planners in northern Europe have increasingly recognized the key role that bicycling plays as a feeder and distributor service for public transport. Thus, copious bike parking is provided at train stations in the city center as well as at outlying stations along the rail network. In cities such as Muenster, many suburban residents use a bike to reach the nearest suburban rail station, park it there, and then take the train to the city center, where they continue their trip with another bike they have parked at the main train station (City of Muenster, 2004). Most rail systems charge an additional fee for cyclists to take their bikes on suburban trains, metros, and trams. Moreover, most systems prohibit bikes on

vehicles during rush hours, and even if permitted, it can sometimes be less convenient than keeping bikes at parking facilities at both ends of the trip.

Most Dutch, Danish, and German cities we surveyed do not permit bikes to be taken onboard regular city buses, and most buses do not come equipped with bike racks (City of Amsterdam, 2007). That contrasts starkly with the USA, where over 50,000 urban transit buses in 2007 had bike racks to facilitate bike and ride (American Public Transportation Association, 2007). It appears to be the one area where American transit systems do a better job of coordinating cycling with transit. The northern European approach is to provide bike parking facilities at major bus terminals, bus route interchanges, and even some suburban bus stops. Bike-and-ride facilities at bus stops are not nearly as extensive, secure, and comfortable as those at rail stations, but they help offset the lack of bike racks on buses.

Another form of bike-transit integration is the provision of bike rentals at virtually every major Dutch, Danish, and German train station and many suburban stations as well. The German Railways “Call a Bike” program in Berlin is especially innovative. It permits anyone with a mobile phone and credit card to rent one of more than 3,000 German Rail bikes placed all over the city. One simply calls up the “Call a Bike” number, provides credit card information (charged per minute of bike use), and then receives the access code used to unlock the bike (German Railways, 2007). The bike can be left at many different locations throughout the city instead of being returned to the point of origin. The same “Call a Bike” service is offered by German Railways in other major cities such as Stuttgart, Cologne, Frankfurt, and Munich, with a total of over 10,000 such rental bikes.

Training and Education. Dutch, Danish, and German children receive extensive training in safe and effective cycling techniques as part of their regular school curriculum. Most children complete such a course by the fourth grade. It includes both classroom instruction and “on the road” lessons, first on a cycling training track just for children, and then on regular cycling facilities throughout the city. Real police officers test the children, who receive official certificates, pennants, and stickers for their bikes if they pass the test. Since many children get to school by bike, training in safe cycling is considered essential to ensure their safety (German Federal Ministry of Transport, 2002). But it also gets kids off to a lifetime of safe cycling skills. And since all schoolchildren are included, it means that girls as well as boys start cycling at an early age.

Another crucial element in cyclist safety is training motorists to be aware of cyclists on the roadway and to avoid endangering them. In general, motorist training in the Netherlands, Denmark, and Germany is far more extensive, more thorough, and more expensive than in the USA. Motorists are legally responsible for collisions with children and elderly cyclists (German Federal Ministry of Transport, 2002; Netherlands Ministry of Transport, 2006), even if they are jaywalking, cycling in the wrong direction, ignoring traffic signals, or otherwise behaving contrary to traffic regulations. The priority legal status of non-motorists puts motorists on the defensive and forces them to drive with special attention to avoiding endangering cyclists and pedestrians.

Traffic Laws. As suggested by the previous section, traffic laws in the Netherlands, Denmark, and Germany give special consideration to the especially vulnerable situation of cyclists vis-à-vis motor vehicles (German Federal Ministry of Transport, 2006). Thus, they generally require the motorist to make special efforts to

anticipate potentially dangerous situations and pro-actively avoid hitting cyclists. Moreover, motorists are generally assumed to be legally responsible for most collisions with cyclists unless it can be proven that the cyclist deliberately caused the crash. Having the right of way by law does not excuse motorists from hitting cyclists, especially children and elderly cyclists.

For the most part, traffic laws intended to protect cyclists and pedestrians from motor vehicles are far more strictly enforced by the police and courts in the Netherlands, Denmark, and Germany than in the USA. Moreover, cyclists disobeying traffic laws are also more likely to be ticketed than in the USA. In combination with comprehensive and rigorous training of motorists and cyclists, the strict enforcement of traffic laws surely contributes to safer driving behavior by motorists and safer cycling by cyclists.

Promotional Events. Although the provision of safe and convenient cycling facilities is the key approach to promoting cycling, virtually all Dutch, Danish, and German cities have various programs to stimulate interest and enthusiasm for cycling by all groups. Table 2 includes a partial listing of typical promotional measures used by six cities we specifically surveyed: Amsterdam and Groningen (Netherlands), Copenhagen and Odense (Denmark), and Berlin and Muenster (Germany). There were many other creative and interesting programs as well, but Table 2 conveys the sorts of promotional measures undertaken.

Promotional activities tend to be more extensive in Denmark and Germany than in the Netherlands, where cycling levels are already so high that the focus is more on safer cycling than on more cycling, although the two are directly related, as noted earlier.

Complementary taxation, parking, and land-use policies

Most of the above policies refer to measures that make cycling safer and more convenient. But there are other important factors that encourage cycling indirectly (Dutch Bicycling Federation, 2006; Netherlands Ministry of Transport, 2006; Pucher and Dijkstra, 2003; Pucher and Buehler, 2006). For example, sales taxes on petrol and new car purchases, import tariffs, registration fees, license fees, driver training fees, and parking fees are generally much higher in Europe than in the USA. That results in overall costs of car ownership and use roughly twice as high in Europe, but with variations from one country to another (Organisation for Economic Cooperation and Development, 2007; Banister, 2005; Banister et al, 2007; Transportation Research Board, 2001). That higher cost should discourage car use to some extent and thus promote alternative ways of getting around, including cycling, which is surely one of the cheapest of transport modes. With petrol taxes and prices in the UK among the highest in Europe, one might expect the British to cycle much more than for one percent of their trips. Clearly, there are other factors in the UK that encourage car use and deter cycling.

There are a range of other government policies that differentiate the UK from the Netherlands, Denmark, and Germany and appear to encourage more car use (McClintock, 2002; Tolley, 2003; Banister, 2005; Banister et al, 2007; Goodwin, 1999). Interviews conducted by the authors in 2007 with a wide range of transport specialists throughout the UK suggest that British metropolitan areas have a greater supply of motorways and car parking than is typical of the Netherlands, Denmark, and Germany. The experts we interviewed indicated that car-free city centers are less common in the UK, traffic calming of residential neighborhoods is less widespread, urban speed limits are generally

higher, and many firms provide tax-induced financial incentives to buy cars and drive them to work. Moreover, land use controls tend to be less strict than in the rest of northern Europe. The lack of good coordination between land use and transport has resulted in more low-density suburban sprawl, often strewn along the extensive motorway system surrounding most British cities (Banister, 2005). Clearly, none of the above factors is conducive to cycling. Combined with the lesser extent and inferior quality of cycling facilities in most British cities, these less favorable underlying conditions might help explain why only one percent of trips in the UK are made by bike.

As described earlier in this paper, cities in the Netherlands, Denmark, and Germany impose extensive restrictions on car use and parking that reduce the relative speed, convenience, and flexibility of car travel compared to cycling. American cities have not even come close to those sorts of restrictions, and with the exception of London, most British cities have facilitated car use rather than restricting it (Transportation Research Board, 2001; Banister, 2005).

Finally, land use and urban design policies in Dutch, Danish, and German cities are much stricter than in the USA and provide more government controls on low-density sprawl and the long trip distances that usually generates (Dutch Bicycling Federation, 2006; Netherlands Ministry of Transport, 2006; Transportation Research Board, 2001). Moreover, mixed-use zoning and transit-oriented developments have a long history in the Netherlands, Denmark, and Germany. They facilitate the proximity of residential areas to commercial establishments, schools, churches, and a range of services. The resulting trip distances are shorter and thus more bikeable than those in the USA.

Conclusions: Policies to Make Cycling Possible for Everyone

The most important approach to making cycling safe, convenient, and attractive for everyone in Dutch, Danish, and German cities is the provision of separate cycling facilities along heavily traveled roads and at intersections, combined with extensive traffic calming of residential neighborhoods. Safe and relatively stress-free cycling routes are especially important for children, the elderly, women, and for anyone with special needs due to any sort of disability. Providing such separate facilities to connect practical, utilitarian origins and destinations also promotes cycling for work, school, and shopping trips, as opposed to the mainly recreational cycling in the USA, where most separate cycling facilities are along urban parks, rivers, and lakes or in rural areas.

As noted in this article, separate facilities are only part of the solution. Dutch, Danish, and German cities reinforce the safety, convenience, and attractiveness of excellent cycling rights of way with extensive bike parking, integration with public transport, comprehensive traffic education and training of both cyclists and motorists, and a wide range of promotional events intended to generate enthusiasm and wide public support for cycling.

At the same time, car use is made expensive and less convenient through a host of taxes and restrictions on car ownership, use, and parking. And land use policies foster relatively compact, mixed-use developments that generate more bikeable, shorter trips.

The key to the success of cycling policies in northern Europe is the coordinated implementation of this multi-faceted, self-reinforcing set of policies. Precisely because the policies are sensitive to the very different needs of different social groups, they also

succeed in making cycling possible for virtually everyone. It is a lesson still to be learned in the USA and the UK.

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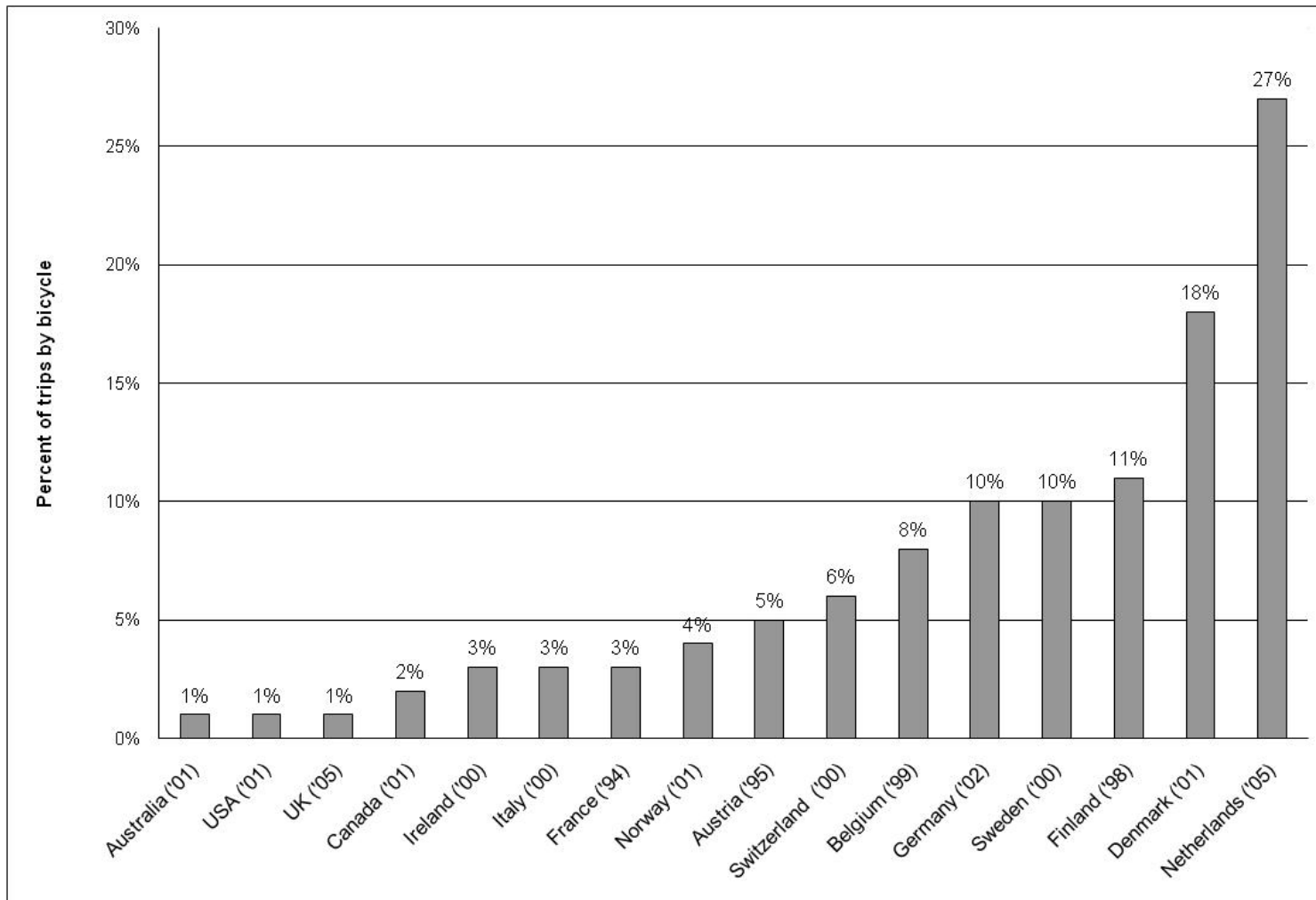


Figure 1. Bicycle share of trips in Europe, North America, and Australia (Percent of total trips by bicycle)

Source: European Conference of the Ministers of Transport (2004); European Union (2003); U.S. Department of Transportation (2003); Netherlands Ministry of Transport (2006), German Federal Ministry of Transport (2003); Department for Transport (2005)

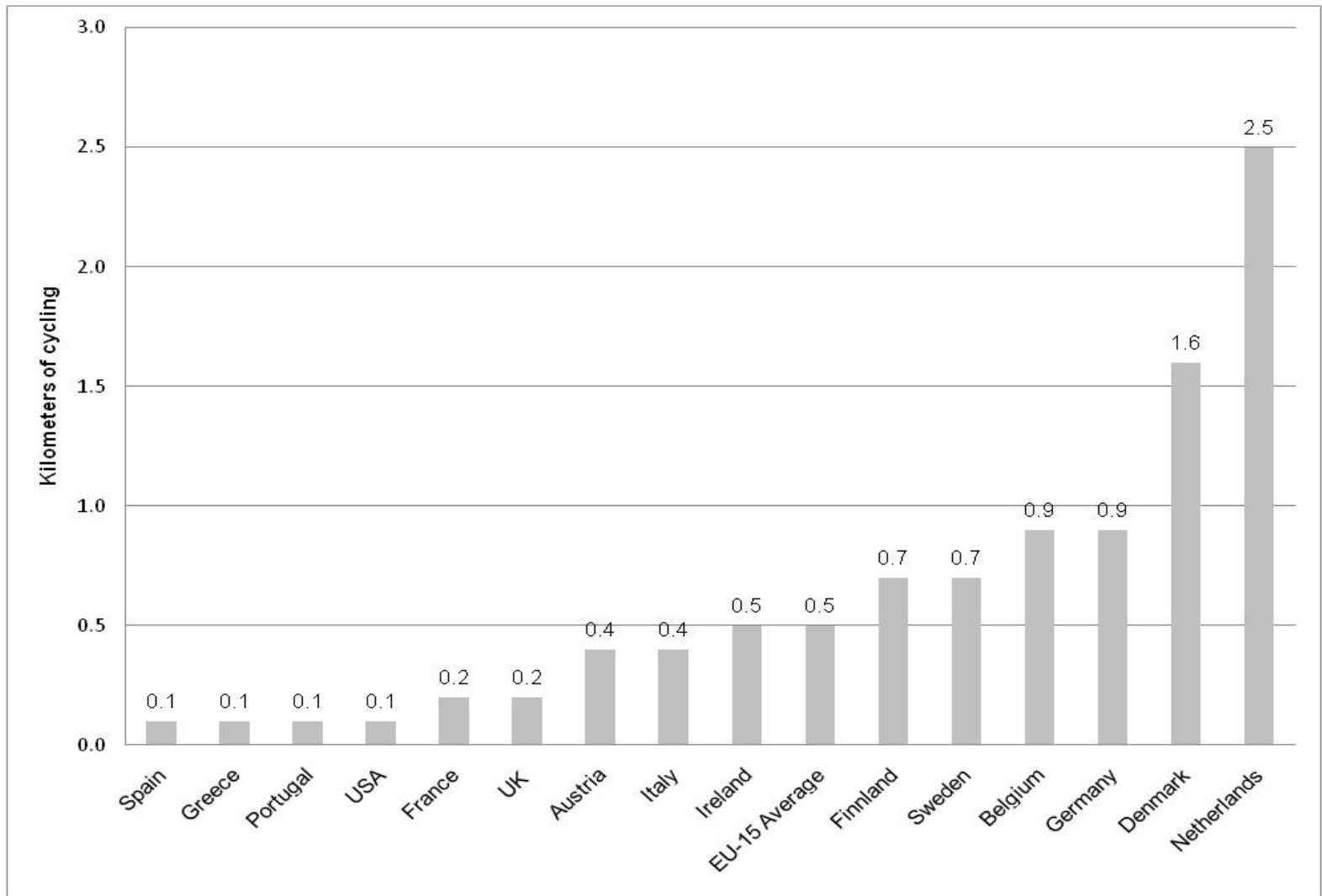


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Source: European Union (2002)

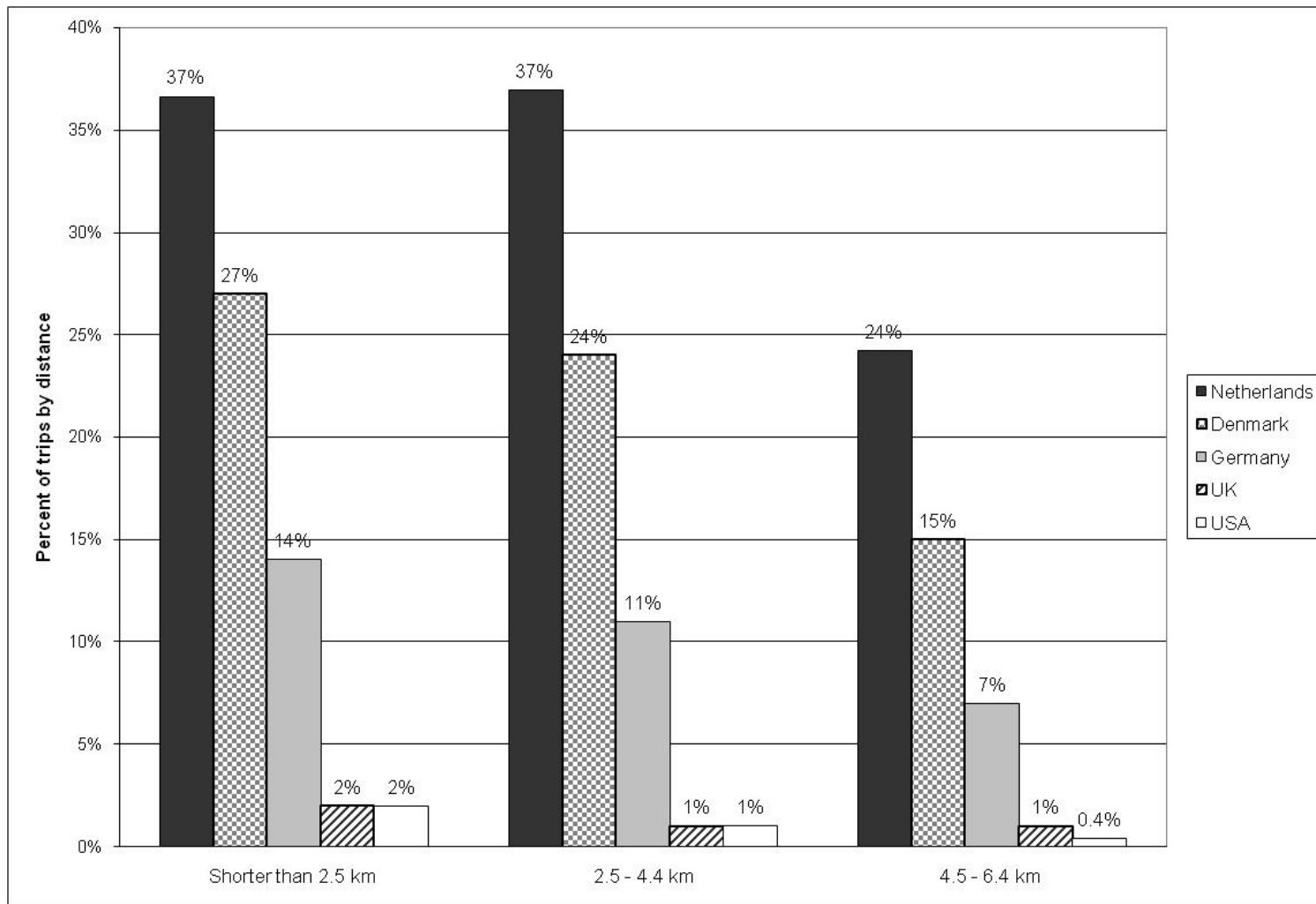


Figure 3. Bicycling share of short trips in the Netherlands, Denmark, Germany, the USA, and the United Kingdom (2000-2005)

Sources: Danish Ministry of Transport (2007); Netherlands Ministry of Transport (2006); U.S. Department of Transportation (2003); German Federal Ministry of Transport (2003); Department for Transport (2005)

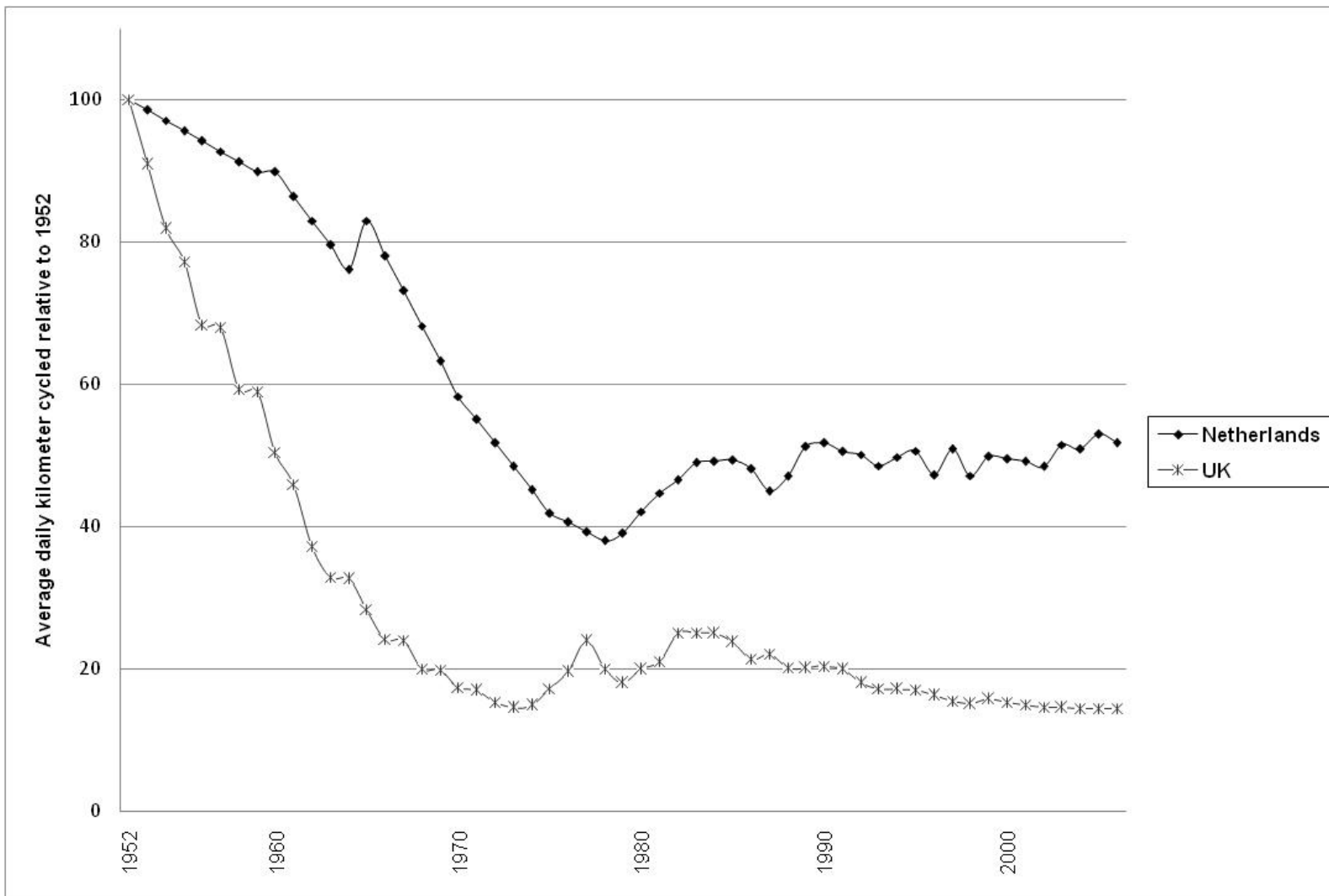


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Sources: Netherlands Ministry of Transport (2007); Department for Transportation (2007)

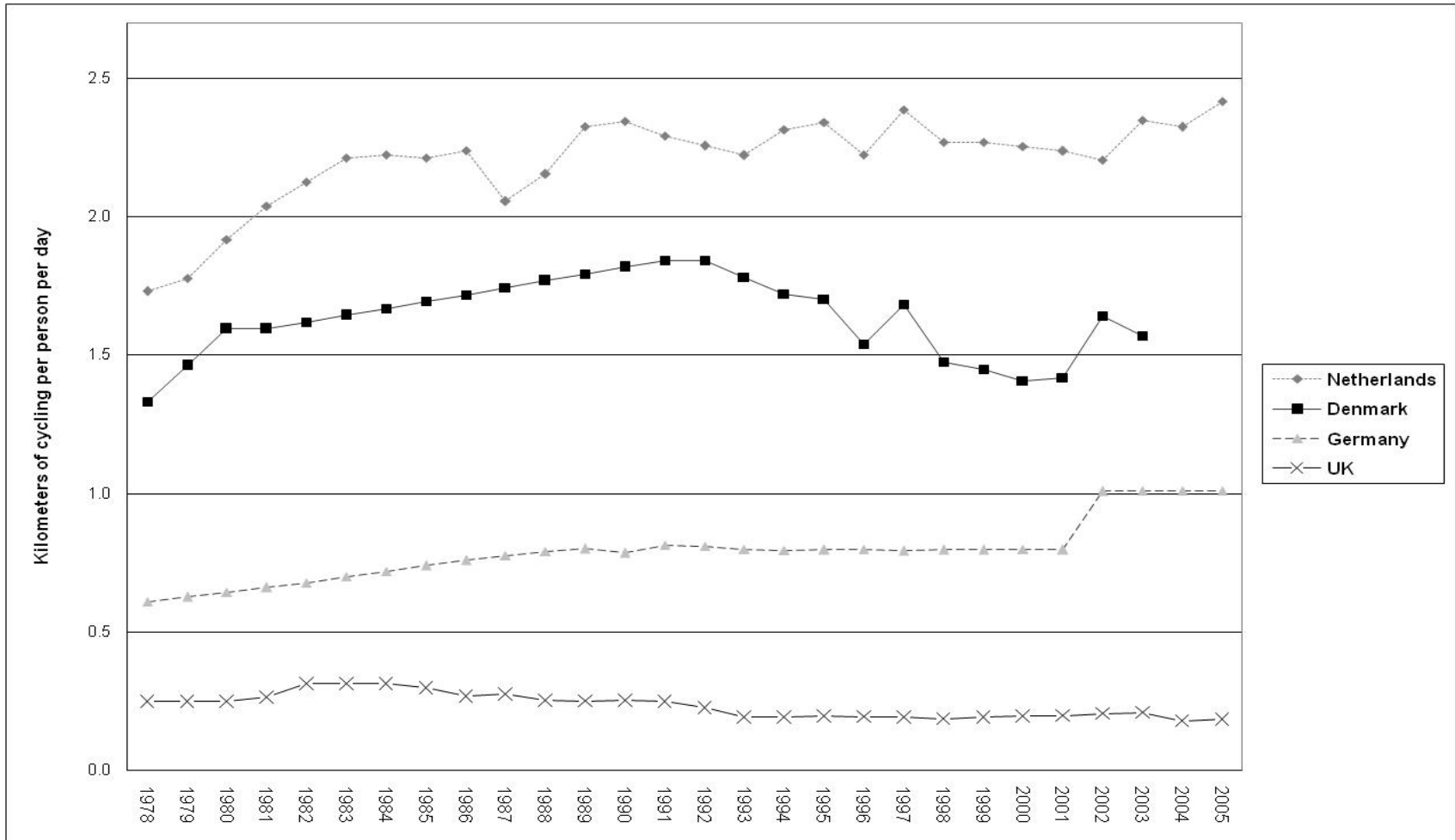


Figure 5. Trend in kilometers cycled per inhabitant per day in the Netherlands, Denmark, Germany and the United Kingdom (1978-2005)

Sources: Danish Ministry of Transport (2007), Netherlands Ministry of Transport (2007); German Federal Ministry of Transport (2007); Department for Transportation (2007)

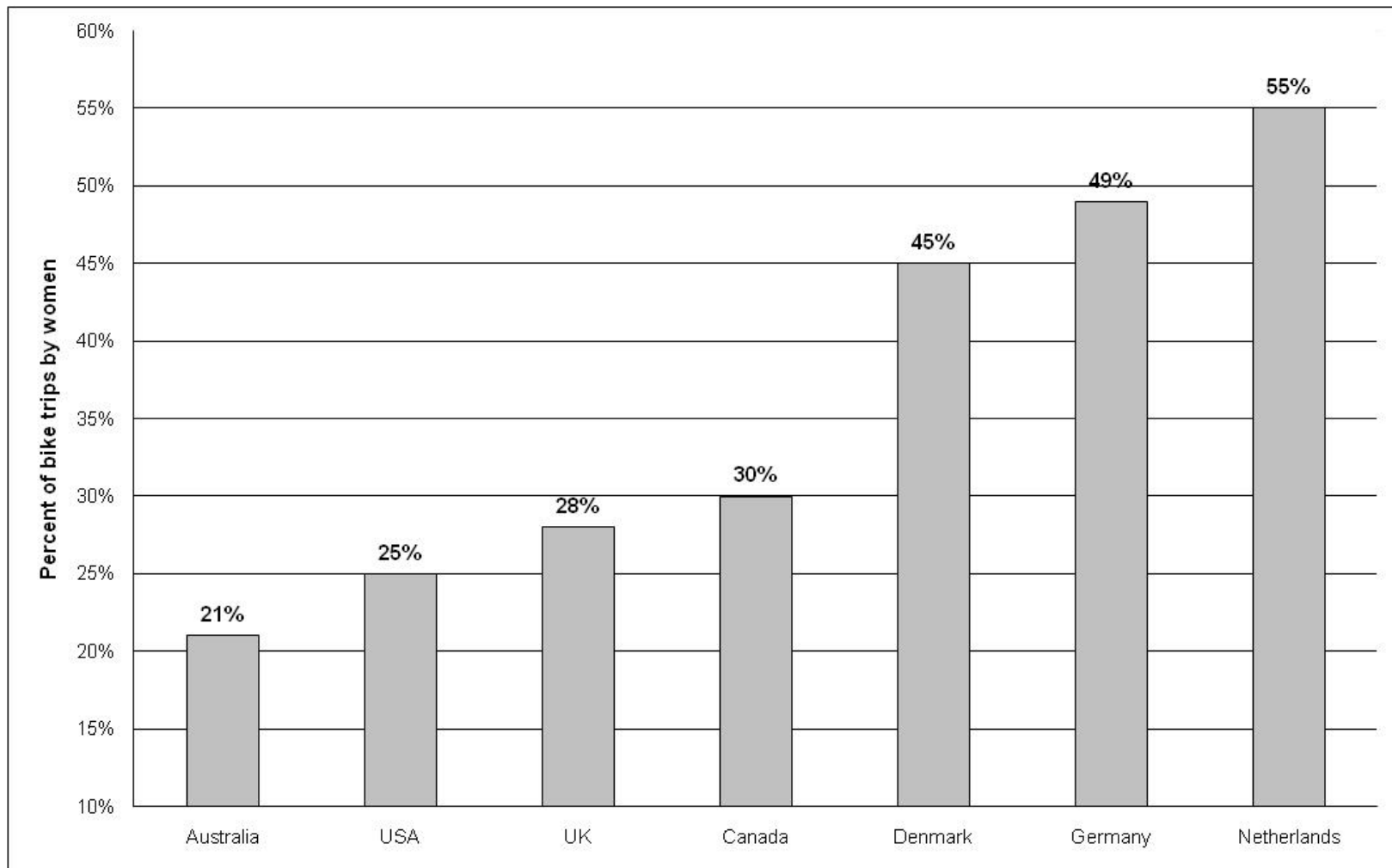


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Sources: German Federal Ministry of Transport (2003); U.S. Department of Transportation (2003); Australian Statistical Office (2005); Danish Statistical Office (2005); Statistics Netherlands (2005); Department for Transport (2007); and information provided directly by bike planners in Canadian provinces and cities

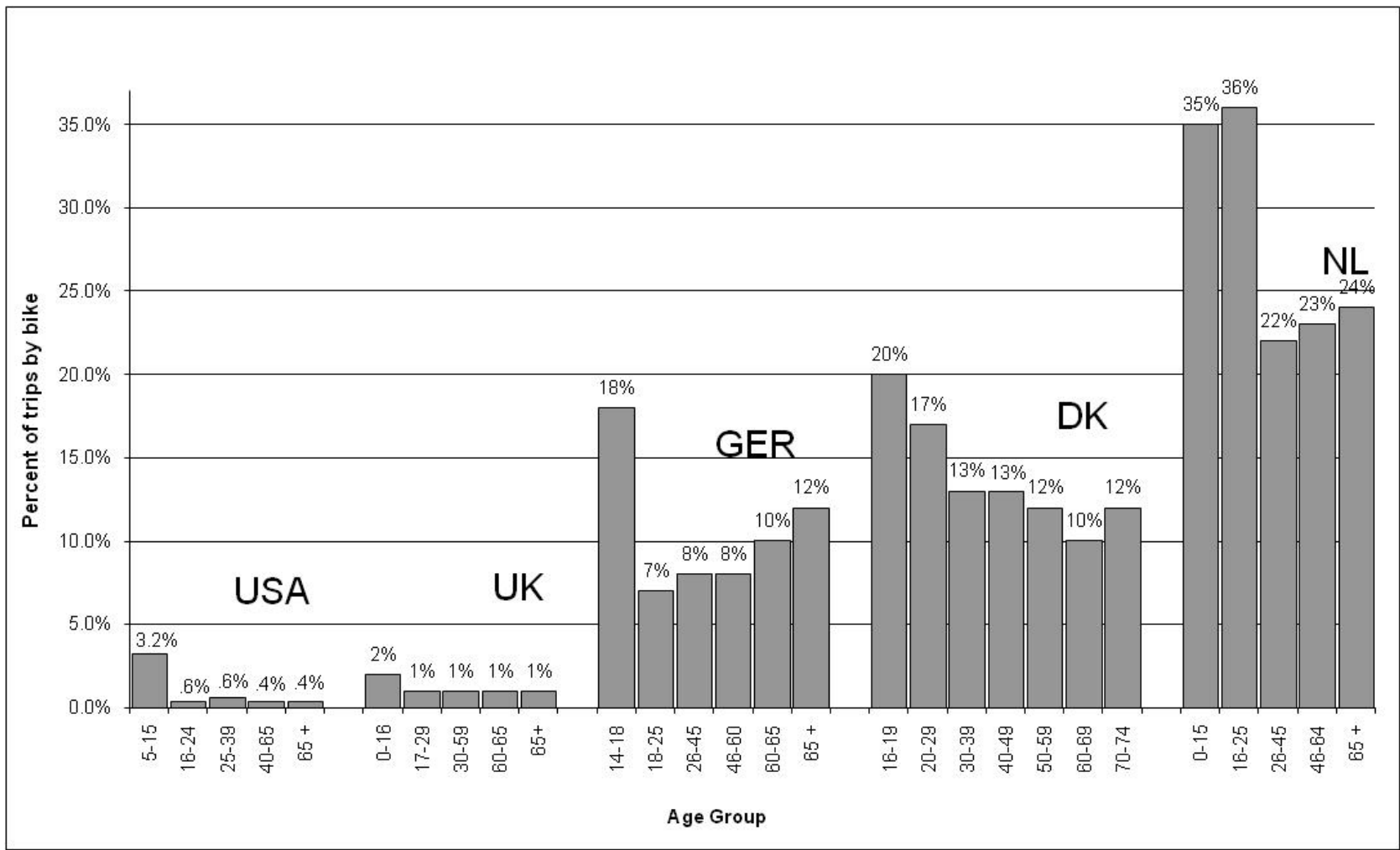


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Sources: German Federal Ministry of Transport (2003); U.S. Department of Transportation (2003); National Statistical Offices of Denmark (2005); Statistics Netherlands (2005); Department for Transport (2007)

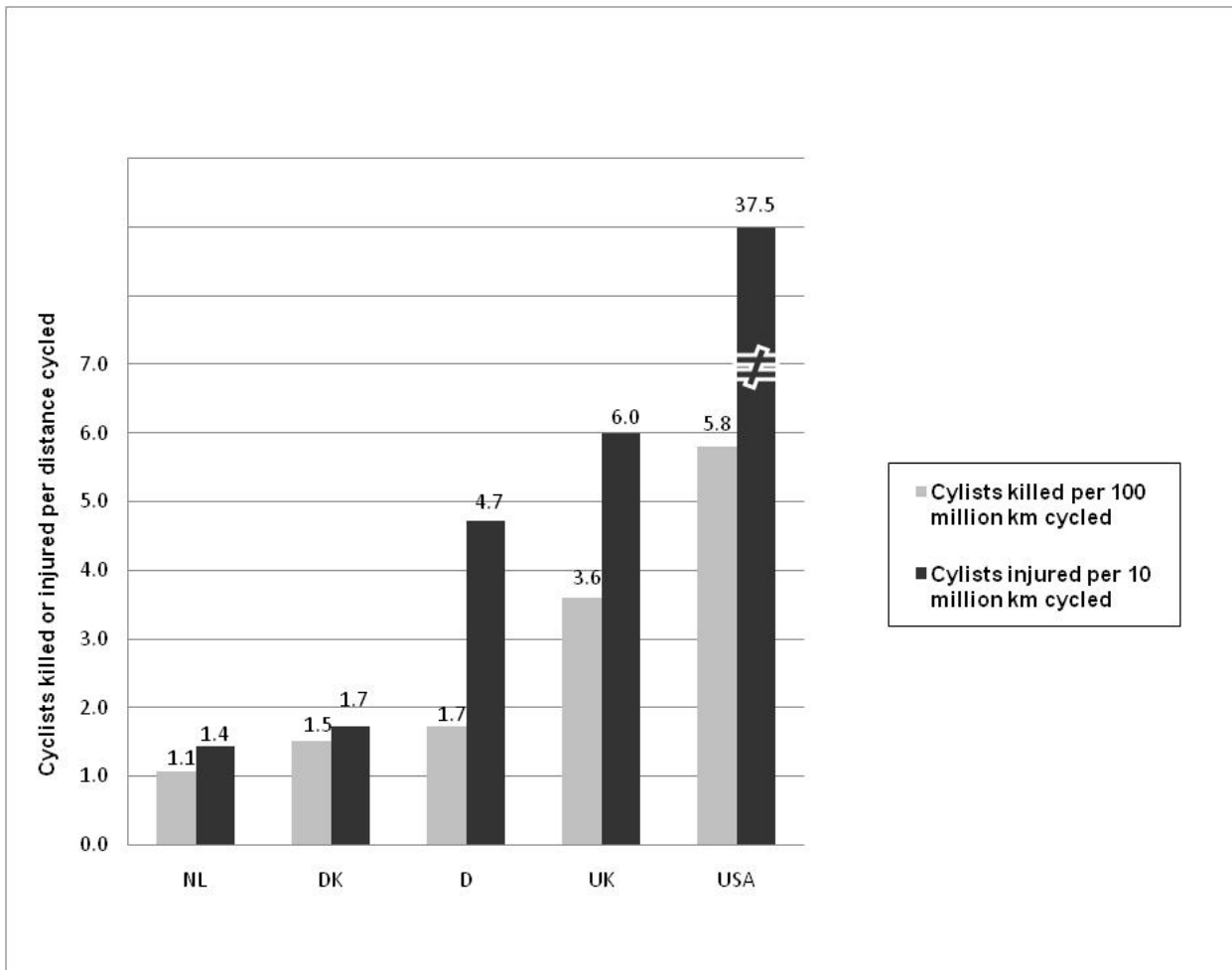


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Sources: Danish Ministry of Transport (2007); Netherlands Ministry of Transport (2007); German Federal Ministry of Transport (2007); U.S. Department of Transportation (2007); Department for Transportation (2007)

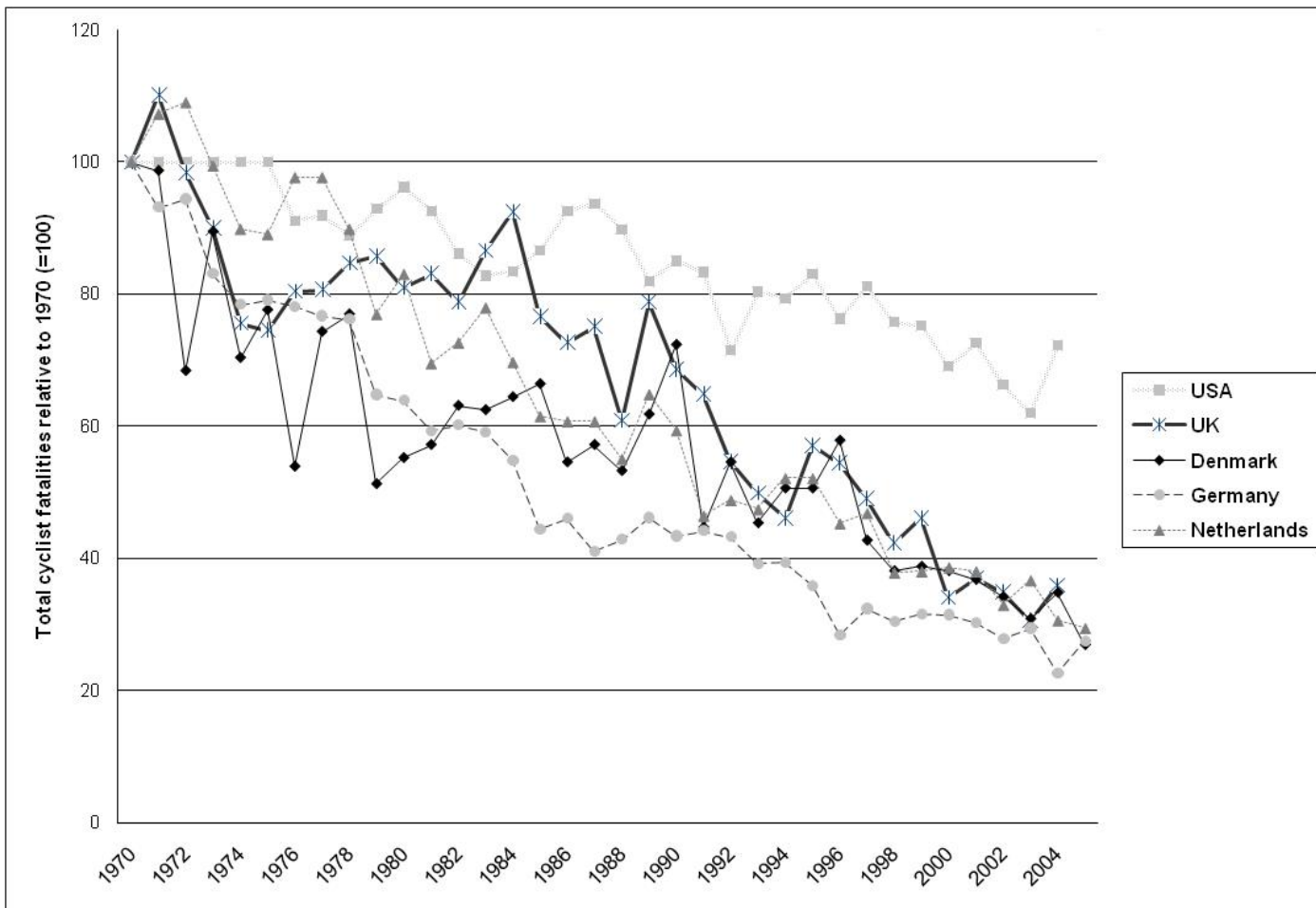


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Sources: Danish Ministry of Transport (2007); Netherlands Ministry of Transport (2007); German Federal Ministry of Transport (2007); U.S. Department of Transportation (2007); Department for Transport (2007)

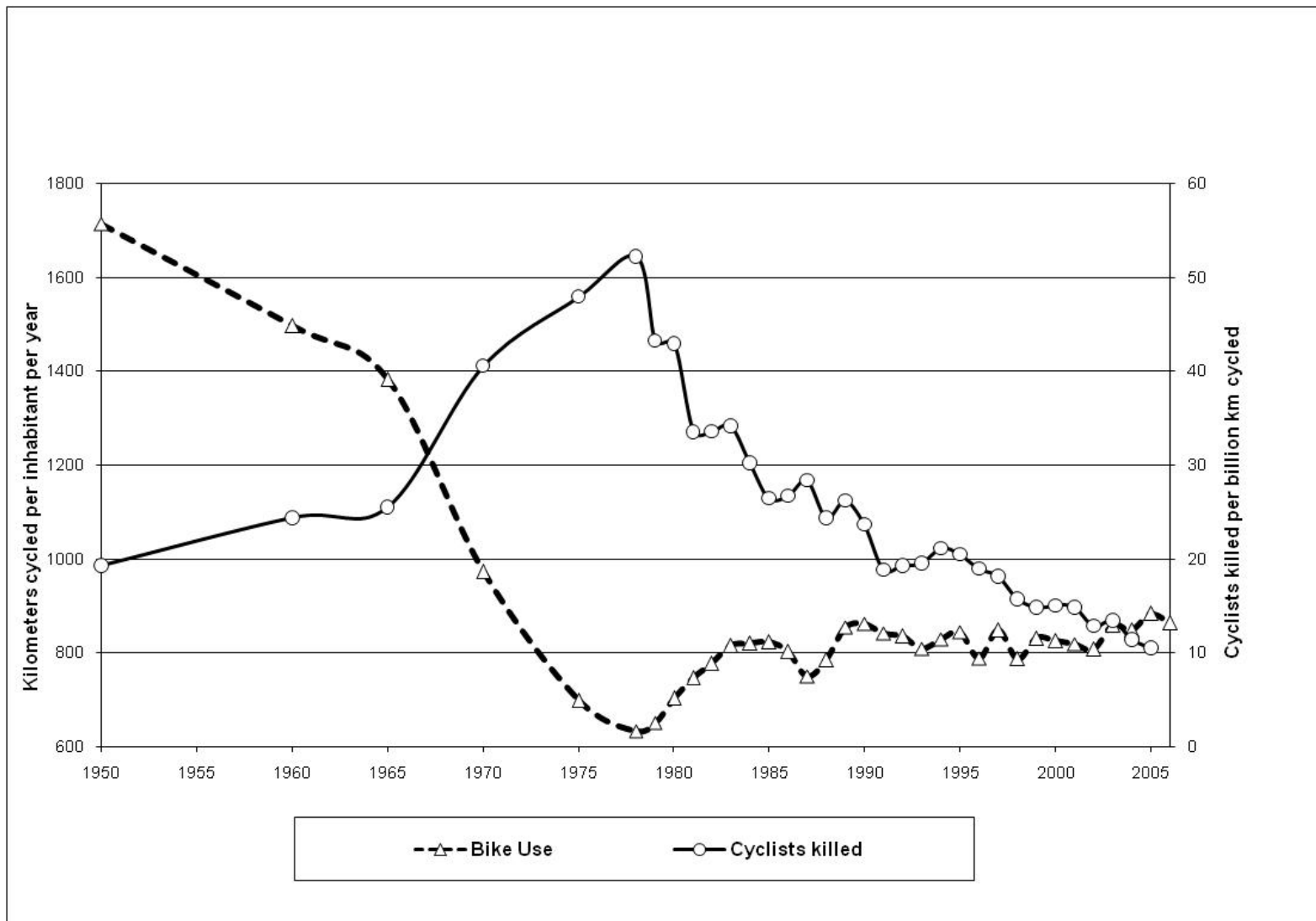


Figure 10. Inverse trends in cycling fatality rates and annual kilometers cycled per inhabitant in the Netherlands, 1950 to 2005

Source: Netherlands Ministry of Transport (2007)

Table 1. Key policies and innovative measures used in Dutch, Danish, and German cities to promote safe and convenient cycling

Extensive systems of separate cycling facilities

- Well maintained, fully integrated paths, lanes and special bicycle streets in cities and surrounding regions
- Fully coordinated system of color coded directional signs for bicyclists
- Off-street short-cuts, such as mid-block connections, and passages through dead ends for cars

Intersection modifications and priority traffic signals

- Advance green lights for cyclists at most intersections
- Advanced cyclist waiting positions (ahead of cars) fed by special bike lanes facilitate safer and quicker crossings and turns
- Cyclist short cuts to make right-hand turns before intersections and exemption from red traffic signals at T-intersections, thus increasing cyclist speed and safety
- Bike paths turn into brightly colored bike lanes when crossing intersections
- Traffic signals are synchronized at cyclist speeds assuring consecutive green lights for cyclists (green wave)
- Bollards with flashing lights along bike routes signal cyclists the right speed to reach the next intersection at a green light

Traffic calming

- Traffic calming of all residential neighborhoods via speed limit (30km/h) and physical infrastructure deterrents for cars
- Bicycle streets, narrow roads where bikes have absolute priority over cars
- "Home Zones" with 5 km/h speed limit, where cars must yield to pedestrians and cyclists using the road

Bike parking

- Large supply of good bike parking throughout the city
- Improved lighting and security of bike parking facilities often featuring guards, video-surveillance, and priority parking for women

Coordination with public transport

- Extensive bike parking at all metro, suburban, and regional train stations
- "Call-a-Bike" programs: bikes can be rented by cell phone at transit stops, paid for by the minute and left at any busy intersection in the city
- Bike rentals at most train stations
- Deluxe bike parking garages at some train stations, with video surveillance, special lighting, music, repair services, and bike rentals

Traffic education and training

- Comprehensive cycling training courses for virtually all school children with test by traffic police
- Special cycling training test tracks for children
- Stringent training of motorists to respect pedestrians and cyclists and avoid hitting them

Traffic laws

- Special legal protection for children and elderly cyclists
- Motorists assumed by law to be responsible for almost all crashes with cyclists
- Strict enforcement of cyclist rights by police and courts

Source: Information provided directly to authors by bicycling coordinators in the Netherlands, Denmark, and Germany.

Table 2. Cycling promotion in the Netherlands, Denmark, and Germany

- Bicycling websites with extensive information for cyclists on bicycling routes, activities, special programs, health benefits of cycling, bike and bikes and bike accessories, etc.
- Flexible internet bike trip planning tool allows finding the most comfortable or quickest route by bike
- Free use of distinctive, simple City Bikes parked throughout the city, as in Copenhagen
- Regular surveys of cyclists to assess their satisfaction with cycling facilities and programs and to gather specific suggestions for improvement
- Focus on health benefits of cycling, such as the “Get Rid of the Sack” program in Odense targeted at overweight middle-aged men with pot bellies
- Company bikes loaned for free to employees who can use them during the day for short business trips
- Special fun programs for young children, such as the “Cycling Duckie” in Odense, who distributes candy, balloons, free bike accessories, and other gifts
- Convenient air pumps in city center for bike tires
- Bike councils that provide a platform for opinion exchange among stakeholders from businesses, the bike industry, the city administration, research institutes, universities, bike experts, and citizen advocacy groups, such as the "Fahrrat" in Berlin
- Comprehensive bike maps for every part of the city and the surrounding region
- Cycling ambassador programs that send well-trained cyclists to residential neighborhoods to serve as role models of safe cycling and help with cycling promotion, distributing newsletters and information about cycling events
- Annual bicycling festivals and car-free days that promote the environmental advantages of bicycling, display the latest bike models and accessories, disseminate various other relevant information for bike enthusiasts, and offer a range of bike races and
- Wide range of cycling competitions for different ages and skill levels
- "Park and Bike" : discount bike rentals for motorists who park their cars and bike for the rest of the journey

Source: Information provided directly to authors by bicycling coordinators in the Netherlands, Denmark, and Germany.